Technology Focus: Data Acquisition

Hidden Identification on Parts: Magnetic Machine-Readable Matrix Symbols

These symbols could be read even when covered with paint.

Marshall Space Flight Center, Alabama

Have you ever seen a piece of spaceflight hardware? When you do, you will notice some letters and numbers etched or inscribed on it. All NASA parts have identification, usually expressed in terms of part number, serial number, and the like. In most cases, this identification is permanently marked directly on the part for tracking throughout its life cycle. The recently approved NASA Technical Standard 6002 and Handbook 6003 (found at ***http://standards.nasa.gov***) added the matrix symbol to the identification scheme as shown in Figure 1. This put a checkerboard bar code on the part so that an optical scanner could read it. The intent was to make tracking parts as easy as checking out at the grocery store. The system works well as long as the matrix symbol is visible.

But what if the matrix symbol identification gets covered with paint or a similar coating? NASA has developed a method for reading the matrix symbol through up to 15 mils (25 µm) of paint (5 or 6 layers). This method of part identification involves coating selected patches on the objects with magnetic materials in matrix symbol patterns and reading the patterns by use of magneto-optical imaging equipment. The hand-held magnetic scanner, shown in Figure 2, is easy to use and is commercially available through a NASA licensee. It decodes the matrix symbol just like any other scanner. The magnetic marks can be read under conditions that would render optical methods useless. For example, the magnetic scanner can read magnetic marks in the dark or under bright ambient light that might interfere with optical reading of visible marks, symbols that are obscured by discoloration or contamination, in addition to symbols that are covered by paint. Furthermore, inasmuch as magnetic marks can be hidden from unaided view, they are less likely to be deliberately damaged or destroyed. They can even be hidden deliberately for security reasons.

Magnetic material can be applied as viscous ink or paste and even can be

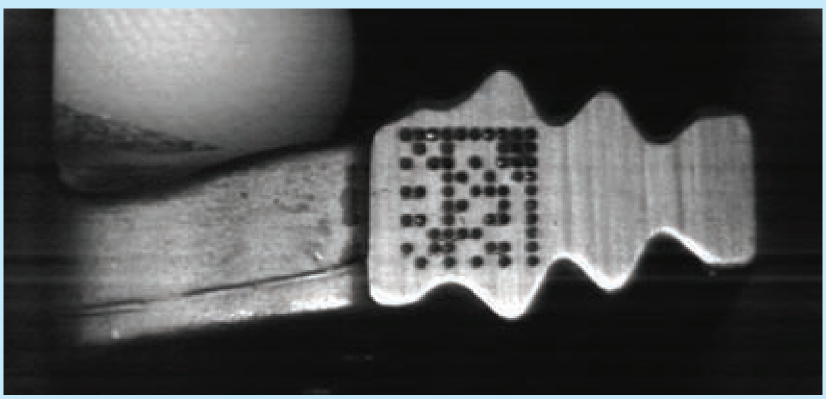


Figure 1. A **Space Shuttle Component** shows matrix symbol identification markings.

Figure 2. This **Hand-Held Scanner** would contain all the equipment (except a source of electric power) needed to read and decode magnetic matrix symbols.

mixed with spray paint. The magnetic material should be one of high retentivity and high coercivity. The matrix symbol pattern can be defined by use of a stencil, or recesses to hold the magnetic material in the matrix symbol pattern can be formed by laser engraving, machine engraving, micro-abrasive blasting, laser etching, or any other suitable marking method. If the magnetic material as applied is not magnetized strongly enough to enable reliable detection over time, it can be magnetized again by use of a permanent magnet or electromagnet.

Bar codes were seldom seen before 1975 but are now common in every commercial outlet. They are on tags and labels of virtually every product. Likewise, direct part marking is now being popularized for tracking things that cannot be labeled. NASA tracks parts using direct part marking. The Department of Defense revised MIL STD 130 to include matrix symbols for direct part marking, and the automotive industry now complies with its B-17 specification for application of matrix symbols on many automobile parts. Now all those little marks that get covered with paint, whether they are on your automobile, jet fighter, weapon, or space shuttle, can be read with ease.

This work was done by Harry F. Schramm and Clyde S. Jones of **Marshall Space Flight Center***; Donald L Roxby and James D. Teed of Rockwell International Corp.; and William C. L. Shih, Gerald L. Fitzpatrick, and Craig Knisely of PRI Research and Development Corp.*

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31013/768.

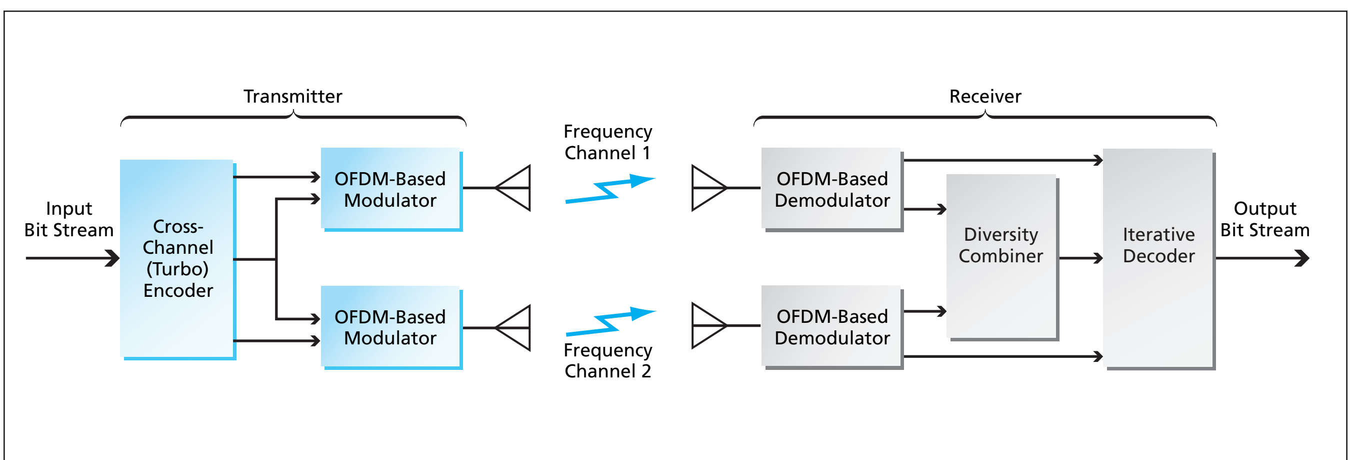
System for Processing Coded OFDM Under Doppler and Fading

Advanced techniques would help to realize the anti-fading potential of OFDM.

NASA's Jet Propulsion Laboratory, Pasadena, California

An advanced communication system has been proposed for transmitting and receiving coded digital data conveyed as a form of quadrature amplitude modulation (QAM) on orthogonal frequency-division multiplexing (OFDM) signals in the presence of such adverse propagation-channel effects as large dynamic Doppler shifts and frequency-selective multipath fading. Such adverse channel effects are typical of data communications between mobile units or between mobile and stationary units (e.g., telemetric transmissions from aircraft to ground stations). The proposed system incorporates novel signal processing techniques intended to reduce the losses associated with adverse channel effects while maintaining compatibility with the high-speed physical layer specifications defined for wireless local-area networks (LANs) as the standard 802.11a of the Institute of Electrical and Electronics Engineers (IEEE 802.11a).

OFDM is a multi-carrier modulation technique that is widely used for wireless transmission of data in LANs and in metropolitan area networks (MANs). OFDM has been adopted in IEEE 802.11a and some other industry standards because it affords robust performance under frequency-selective fading. However, its intrinsic frequency-diversity feature is highly sensitive to synchronization errors; this sensitivity poses a challenge to preserve coherence between the component subcarriers of an OFDM system in order to avoid intercarrier interference in the presence of large dynamic Doppler shifts as well as frequency-selective fading. As a result, heretofore, the use of OFDM has been limited primarily to applications involving small or zero Doppler shifts. The proposed system includes a digital coherent OFDM communication system that would utilize enhanced 802.11a-compatible signal-processing algorithms to overcome effects of frequency-selective fading and large dynamic Doppler shifts. The overall transceiver design would implement a two-frequency-channel architecture (see figure) that would afford frequency diversity for reducing the adverse effects of multipath fading. By using parallel concatenated convolutional codes (also known as Turbo codes) across the dual-channel and advanced OFDM signal processing within each channel, the proposed system is intended to achieve at least an order of magnitude improvement in received signal-to-noise ratio under adverse channel effects while preserving spectral efficiency.



A **Two-Frequency-Channel, Cross-Coded OFDM System** would contain the proposed signal-processing system, parts of which would reside in both transmitting and receiving subsystems.